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Studies of Radiative Penguin B Decays at BaBar

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Abstract. We summarize results on a number of observations of penguin dominated radiative decays of the B meson. Such decays are forbidden at tree level and proceed via electroweak loops. As such they may be sensitive to physics beyond the standard model. The observations have been made at the BaBar experiment at PEP-II, the asymmetric B factory at SLAC.

Keywords. radiative decays, B mesons

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1. Introduction

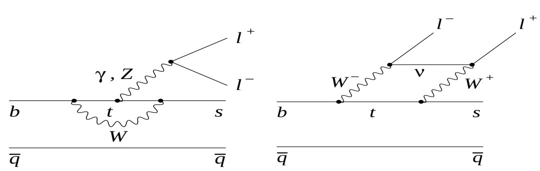

Figure 1. Standard model contributions to penguin dominated decays.

Penguin dominated B decays are decays which proceed via higher order electroweak loops as illustrated in figure 1. Such decays are sensitive to new physics beyond the standard model since the virtual new particles would contribute via loops to graphs that would produce amplitudes that would interfere with the standard mechanism.

2. $B \rightarrow K^{(*)}l^+l^-$

The decay mode $B \rightarrow K^{(*)}l^+l^-$ is a flavor changing neutral current which, in the standard model, is mediated by a class of graphs illustrated in figure 1. The search included both charged and neutral B mesons, K and K^* final states and both electron and muon pairs.

Predictions for this decay rate [1] are about 5×10^{-7} for decays to K and 2×10^{-6} for the decays to K^*. The analysis removes standard model contributions coming from $B \rightarrow K^{(*)}\ J/\psi$, ψ', or γ.

A standard analysis method for B decays at BaBar utilizes the two kinematic variables the beam constrained mass, M_{ES} and ΔE: $M_{ES} = \sqrt{(E^*_{beam})^2 - (p^*_B)^2}$, $\Delta E = (E^*_B -$

E^*_{beam}). The $*$ indicates that the quantiity is calculated in the CM frame (or Υ(4S) rest frame). The rates measured were [1]: $\mathcal{B}(\ B \rightarrow Kl^+l^-\ )$ = $(0.78^{+0.24+0.11}_{-0.20-0.18}) \times 10^{-6}$ (4.4 σ including systematic), $\mathcal{B}(\ B \rightarrow K^*l^+l^-\ )$ = $(1.68^{+0.68}_{-0.58} \pm 0.28) \times 10^{-6}$ (2.8 σ including systematic) or $\mathcal{B}(\ B \rightarrow K^*l^+l^-\ ) < 3.0 \times 10^{-6}$

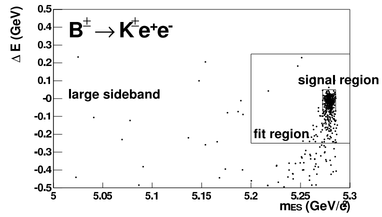

Figure 2. Expected M_{ES} and ΔE distribution from simulated $B^{\pm} \rightarrow K^{\pm}e^+e^-$

3. $B \rightarrow K^*\gamma$

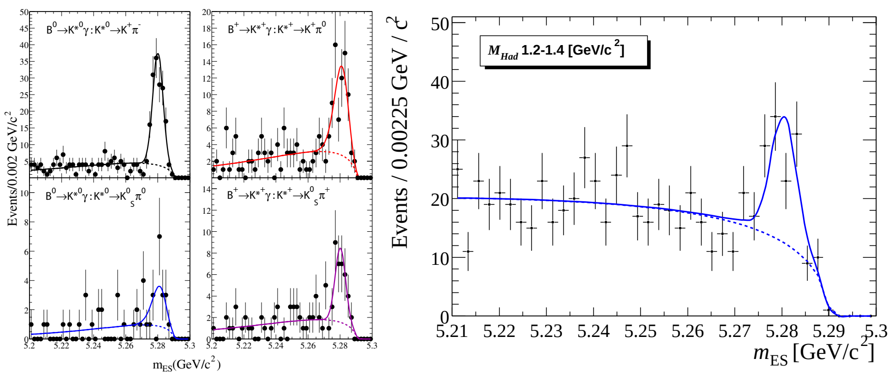

Figure 3. The M_{ES} distribution for the decays $B \rightarrow K^*\gamma$ (left) and typical M_{ES} distribution for the decays $B \rightarrow s\gamma$ (right)

The standard model prediction [2] for this decay is about $7.5 \pm 3.0 \times 10^{-5}$. Event selection [2] is based on finding a localized high energy photon which does not come from π^0 and η decay and does not have a lateral energy profile in the calorimeter characteristic of neutral hadrons. $\mathcal{B}(\ B^0 \rightarrow K^{0*}\gamma\ )$ = $4.23 \pm 0.40 \pm 0.22 \times 10^{-5}$, $\mathcal{B}(\ B^+ \rightarrow K^{+*}\gamma\ )$ = $3.83 \pm 0.62 \pm 0.22 \times 10^{-5}$

4. $b \rightarrow s\gamma$

The expected branching ratio for $b \rightarrow s\gamma$ is in the range [3] $3.29 \pm 0.33 \times 10^{-4}$ to $3.60 \pm 0.33 \times 10^{-4}$. Here we report on two different approaches: a semi-inclusive method

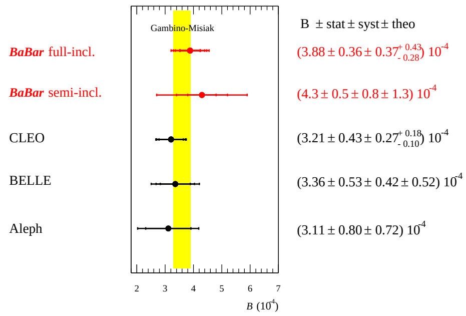

Figure 4. Comparison of results for the decay $b \to s\gamma$.

[4], in which one sums over B decays, or an inclusive analysis [5] where only the photon is measured. The photon definition is similar to that used in the $B \to K^*\gamma$ search.

The semi-inclusive method used twelve modes containing a K^+ or a K_s^0 and up to 3 π but only up to a single π^0. Corrections are made for backgrounds and for undetected modes. In the inclusive method tight cuts were applied to ensure the presence of the other B in the event and the photon energy restricted to the range $2.1 < E_\gamma^* < 2.7$ GeV. A 4±2% correction is applied for contributions coming from $b \to d\gamma$. Results are summarized in figure 4.

5. $B \to \rho\gamma$

The ratio of branching fractions $B \to \rho\gamma$ / $B \to K^*\gamma$ constrains V_{td}/V_{ts}. The present search [7] included $B^0 \to \rho^0\gamma$, $B^+ \to \rho^+\gamma$ and $B^0 \to \omega\gamma$. No signal was found in a search of 84 million B pairs. 90% c.l. bounds on the decays $\mathcal{B}(\,B^0 \to \rho^0\gamma\,) < 1.4 \times 10^{-6}$, $\mathcal{B}(\,B^+ \to \rho^+\gamma\,) < 2.3 \times 10^{-6}$, $\mathcal{B}(\,B^0 \to \omega\gamma\,) < 1.2 \times 10^{-6}$ are still a factor of 2-3 above standard model predicitions.

The combined limit assuming:
$\mathcal{B}(\,B \to \rho\gamma\,) \equiv 2\,\mathcal{B}(\,B^0 \to \rho^0\gamma\,) = 2\mathcal{B}(\,B^0 \to \omega\gamma\,) = \mathcal{B}(\,B^+ \to \rho^+\gamma\,)$ is
$\mathcal{B}(\,B \to \rho\gamma\,) < 1.9 \times 10^{-6}$. Which sets a limit of $\left|\frac{V_{td}}{V_{ts}}\right| < 0.36$.

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